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Seasonal Variation on Physico-Chemical Characteristics of Leachate in Active and Closed Municipal Solid Waste Landfill Site in Lucknow, India

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ABSTRACT

Inappropriate disposal of municipal solid waste (MSW) results in the leaching of inorganic and organic chemicals, which can contaminate the groundwater, posing great contamination risk to humans. Due to unscientific landfilling, many fast growing cities of India are falling under high risk category of groundwater pollution. This paper attempts to assess the physico-chemical characteristics of leachate due to seasonal variation in the active and closed non-engineered MSW landfill sites of Lucknow city of Uttar Pradesh, India. Leachates from different landfill sites, which are either presently active or closed, were characterized and their relationships with season were examined. Concentrations of various physico-chemical parameters such as colour, turbidity, total hardness, electrical conductivity, total dissolved solids, NO_3^{-2}, NH^3-N and SO_4^{2-} were determined in leachate samples.

1) INTRODUCTION

Landfills are one of the major contamination threats groundwater resources not only in India but throughout the world [1]. More than 90% of the Municipal Solid Waste (MSW) generated in India is directly dumped on land in an unsatisfactory manner [2, 3]. Lucknow is capital city of state of Uttar Pradesh in India, with an area of 2528 Sq. Km and a population of about 4.58 million [4]. The solid waste placed in landfills or open dumps are subjected to either groundwater underflow or infiltration from precipitation or any other possibility of infiltration of water. During rainfall, the dumped solid wastes receivers water and the by-products of its decomposition move into the water through the waste deposition. The liquid containing innumerable organic and inorganic compounds is called 'leachate'. The waste dumped at this site includes domestic waste, office waste, institutional waste, commercial waste, restaurant waste, bus stand, railway station e.g. kitchen waste; paper, plastic, poly bags, glass, cardboard and cloths. Construction and demolition waste consisting of sand, bricks and concrete block are also dumped [5]. Further waste from the adjacent poultry market, fish market, slaughterhouse, dairy farm and non-infectious hospital waste is also dumped. The problems associated with handling MSW have increased at an alarming rate over the past few years. Open landfilling in depressed areas is the common method of waste disposal in Lucknow. These landfill sites have not been designed systematically before being used for dumping of waste. No source segregation arrangement exists. Open dumping, without liners and without a leachate management facility, is the normal practice. Besides, no environmental impact assessment has been carried out prior to selection of these sites. The existing sites have been chosen according to the availability of the open areas and ease of operation, ignoring their morpho-landuse suitability. The temperature ranges between 2.8°C (minimum) and 45.4 ◦C (maximum) since year 2000 to 2012. It also experiences heavy rains primarily during the four month of monsoon from June to September and low rain in the month of January. In year 2008 climatology department observed temperature extreamly high and also it rain maximum. The influence of leachate from each type of landfill depended on many factors, including the waste composition, leachate characteristics and precipitation. The quality of leachate from this active and closed uncontrolled landfill was highest at the same time. Leachate characteristic was estimated from an unlined landfill site of Lucknow. In the present study in this paper describing about two landfill of Dubagga and Alliganj site. Various physico-chemical parameters were analyzed in leachate. Municipal Solid Waste includes commercial and residential wastes generated in municipal or notified areas, in either solid or semi-solid form excluding industrial hazardous wastes, but

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including treated bio-medical wastes [6]. The quality and quantity of MSW generated by a particular community varies according to their socio-economic status, cultural habits, urban structure, population and commercial activities. Asian countries are facing MSWM problems due to the rapid growth in MSW generation rate. The daily per capita generation of solid waste depending upon the economic status of the community involved and it mainly involved from household, institutional, street sweeping, contruction and demolition waste. However, landfill has become more difficult to implement because of its increasing cost, community opposition to landfill siting and more restrictive environmental regulations regarding the siting and operation of landfills.

Open dumping is the method of disposing municipal solid waste (MSW) in most of the Asian countries [7]. Solid wastes are disposed of in a manner that does not regard environmental health impact, is susceptible to open burning and exposed to the elements, disease vectors and scavengers [8]. Leachates from open dumps find its way into groundwater [9]. Moreover, the leachate production rate in practice is typically unstable, particularly during the initial stages of stabilization. Further, the understanding of point at which waste is completely degraded and the landfill is stable is not clearly defined [10]. There is a growing list of landfill sites that are known to be leaching contaminants into aquifers [11]. The impact of landfill leachate on the surface and groundwater has given rise to a number of studies in recent years and gained major importance due to drastic increase in population [12]. The dumped solid wastes gradually release its initial interstitial water and some of its decomposition by-product gets into water moving through the waste deposit. Such liquid containing innumerable organic and inorganic compounds is called "Leachate". This leachate accumulates at the bottom of the landfill and percolates through the soil. The leachate problem is made worse by the fact that many landfill sites are still operating without an appropriate impermeable bottom liner or an effective collection and subsequent treatment system [13]. The production of solid wastes in different regions of the world varies from 0.5 to 4.5 kg per person per day, which constitutes an important management problem. Leachate quality may vary from time to time and site to site due to variables such as waste composition, temperature, moisture content, climatic changes etc [14].

2) MATERIAL AND METHOD

The Lucknow Municipal Authorities in Lucknow currently operates a landfill for the disposal of collected urban refuse. In Lucknow there are approximately 23 new and old municipal solid waste dumping sites among which Dubagga and Aliganj sites have been selected for study **(Fig 1)**.

Dubagga landfill lies at 26.47" North and 80.55" East, is located at 160 meter distance in north direction of the Chandoia Village near Musabag and western direction of Lucknow city (**Fig. 2)** is low lying area and close to the fish market and Kadimi Kabristan, receives about 1000 Metric tonnes municipal solid waste daily.

Four years have been passed since dumping started at this site. Large areas near landfill are open so having chances of contaminant rapidely reach into the groundwater by mixing with rain water in the rainy season. Aliganj landfillsite lies at 26.90" North and 80.94" East, is located in the eastern direction of Lucknow city.

Table 1: Some of the important information about the study area

Dumping site	Dubagga	Aliganj
starting period	2007	2000
waste type	MSW	MSW
area (in sq m)	61420.08	100441.96
height (in m)	About 4-5	7-8
Liner	Unlined	Unlined
Condition	Active	Closed
total operation period (in year)	Still now	7
covered by	Uncovered	Uncovered
current landuse	Unused	Unused
Type of area	Semi-urban	Urban

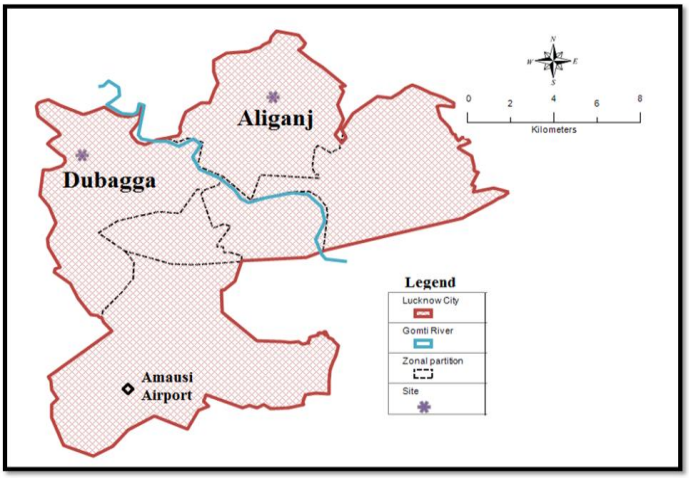

Fig 1: Map window GIS view of dumpsite in Lucknow city

Fig 2: Google Earth view of Dubagga landfill

Eleven years have been passed since dumping started at this site. The disposal site is located in the west of the city near Sitapur road on state highway **(Fig. 3)**. The distance from this road is of approximately 50 meter. The site is having an area of about 100441.96 sq m some of area is using as slum colony.

2.1 Sample collection & storage

The Municipal solid waste was collected from two disposal sites of Lucknow (Uttar Pradesh), India. Since the landfill was not equipped with a leachate collection system, the grab sampling of municipal solid waste was from five different locations within the landfill.

Fig 3: Google Earth view of Aliganj landfill

2.2 Preparation of leachate and preservation

The municipal solid waste samples were pooled, mixed well, air dried, finely ground with a pestal mortar & sieved through a 63 micro m (pore size) sieve to get a homogenous mixture which was used for all studies. The leachate (25%) from municipal solid waste was prepared according to French standard method [15] with slight modification. In brief, 250 g of municipal solid waste was added to 1000 ml of distilled water (w/v) and mixture was then kept on a rotatory shaker at 180 rpm at 30 ± 2^0 C for 24 h for continuous shaking. After shaking, the samples were allowed to settle for 30 min to sediment visible particles, and then filtered with Whatman No. 42 to remove the suspended particles. Finally, undissolved material from the mixture were removed by centrifuging the leachates at 3000 rpm for 15 min. These leachate were used throughout the study. Leachate samples were collected, and it's pH, electrical conductivity etc measured then stored at 4°C and analyzed within 2 days, according to the respective Standard Methods **[16].**

2.3 Physico-Chemical Parameter And Metal Analysis Method of Leachate

Leachate samples were collected, and it's electrical conductivity etc measured then stored at 4°C and analyzed within 2 days, according to the respective Standard Methods [16]. Leachate characteristic such as COD, BOD, TDS, electrical conductivity (µ℧/cm); turbidity (NTU); total hardness; nitrates, ammonical nitrogen, sulphates were determined as per Standard Methods [17]. Precision and accuracy of the analytical data were maintained with triplicate, reagent blank and spiked samples. Frequent calibration of analytical instruments was carried out with working standard solutions. The accuracy of these methods was checked regularly by the application of standard addition methodology, i.e. by adding a known concentration of the respective pollutant to the unknown sample.

3) RESULTS AND DISCUSSION

Leachate is generated due to waste decomposition and rainfall. Contaminant quantity and quality in the leachate depend on waste types and composition. Leachate quality in Dubagga landfill site is showing in **Table 2**.

Physical analysis was carried out to determine colour and turbidity. The results founded in the two study area for leachate are presented in **Table 2** and **Fig. 4** of graphs are showing difference between Mean ± SD in pre and post-monsoon season in the study area.

Colour of the leachate was observed as brownish-black whereas turbidity was estimated to be 281.67 NTU and 208 NTU, whereas in post-monsoon season was and 325.67 NTU and 257.6 NTU. Increased turbidity of leachate could be due to gets disturbed and suspended matter within the landfill site during water withdrawal around landfill. Turbidity values were high in both seasons in the leachate of both sites. However, there was significant difference (P< 0.05) founded in conductivity during pre and post-monsoon season, indicating high load of pollutant in both season. TDS indicates degree of dissolved substances as metal ions in the leachate. Mean value for TDS of leachate was found to be 6396.3 mg/l and 4526 mg/l in pre-monsoon season, whereas in post-monsoon season was 5471 mg/l and 3493 mg/l. This means that TDS are more in pre-monsoon season than post-monsoon season. It is observed that significant difference founded for two seasons, however leachate seems to contain high concentration of sulphate. Mean value for EC of leachate were found to be 9354.6 µ℧/cm and 5735.6 µ℧/cm in pre-monsoon season, whereas in post-monsoon season was and 7420 µ℧/cm and 4566.6 µ℧/cm. In the post-monsoon conductivity founded decrease of the pre-monsoon season. This is a common phenomenon, where a decrease in conductivity is a response to a decrease in the concentration through dilution by rainwater [18].

Table 2: Average (mean) values, range and analytical measurements of various parameters of leachate quality

Parameter	Unit	Pre-monsoon		Post-monsoon	
		Dubagga	Aliganj	Dubagga	Aliganj
		Mean±SD	**Mean**±SD	**Mean**±SD	**Mean**±SD
Turbidity	NTU	281.67 ± 10.4	208±12.1	325.67 ± 6.02	257.6±7.5
TDS	mg/l	6396.3 ± 77.9	4526±51.1	5471 ±73.3	3493±30.8
EC	℧/cm	9354.6 ± 85.4	5735.6±62.9	7420±58.1	4566.6±52.5
TH	mg/l	2909.6 ±61.5	2470.3±79.1	2227.6 ±52.3	2024.3±87.5
BOD	mg/l	2381.67 ±53.72	206.33±24.01	1724.33 ±51.93	149.67±21.59
COD	mg/l	3548 ±98.53	1147±92.6	2823.33 ±92.51	984.67 ±90.09
SO_4^{2-}	mg/l	1643 ± 23	1433±21.5	1147 ±20.2	929±19.4
NO_3^-	mg/l	933 ±31.6	744±22	536.8 ±25.7	571.9±20.2
NH^3-N	mg/l	188.3 ±3.2	149±3.6	156±4	132.6±4

Mean value for TH in the two study area for leachate were found to be 2909.6 mg/l and 2470.3 mg/l in pre-monsoon season, whereas in post-monsoon season was 2227.6 mg/l and 2024.3 mg/l. Mean value for BOD of leachate were found to be 2381.67 mg/l and 206.33 mg/l in pre-monsoon season, whereas in post-monsoon season was 1724.33 mg/l and 149 mg/l. According to the results the decomposition of the organic matter is high in starting stage due to MSW having

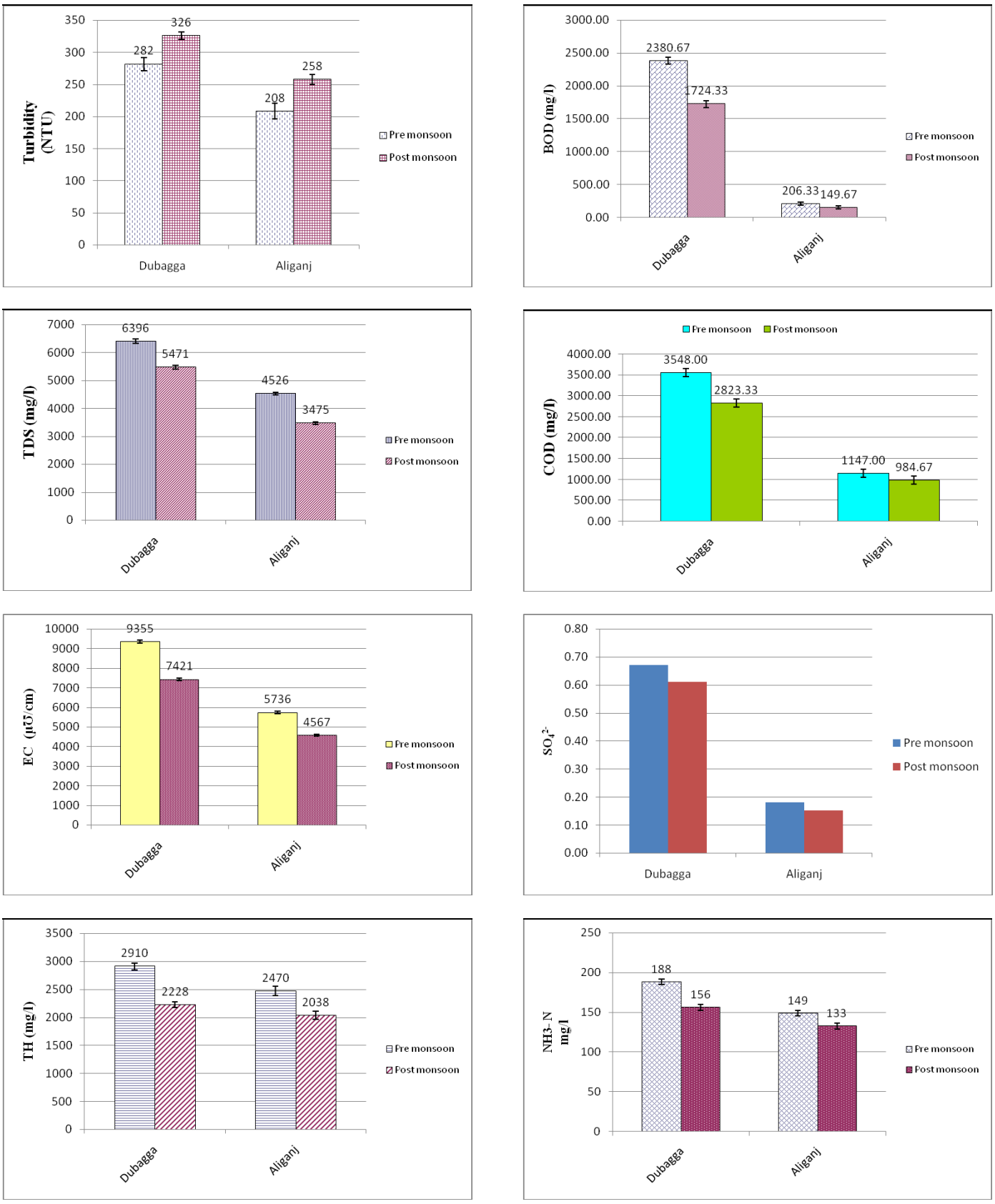

Fig 4: Graphs are showing difference between Mean ± SD in pre and post-monsoon season in the study area

high amount of fresh organic matter. Results of BOD showed highly increasing concentration after monsoon due to high moisture content. It is found that increase in BOD shows high content of organic matter which gets biodegraded after monsoon season. COD was estimated to be 3548 mg/l and 1147 mg/l in pre-monsoon season, whereas in post-monsoon season was 2823.33 mg/l and 984.67 mg/l. BOD, COD and BOD/COD are the parameter which is used to measure the organic content in the leachate. CPCB and NEERI in 2002 have been reported the presence of 6000-8000 mg/l concentration of COD in the leachate of MSW from Gandhi Setu. Mean value for BOD/COD was founded 0.67 and 0.18 in pre-monsoon season, whereas in post-monsoon season was 0.61 and 0.15. BOD/COD ratio have been used to estimate waste decomposition which is organic indicator. This ration in Dubagga leachate indicating high in comparision to Aliganj leachate. This means that most of the organic matter is biodegradable [19]**.** As time passes most probably chances of BOD/COD decreases. The value of BOD/COD greater than 0.4 indicating good biodegradability [20]. The results also indicating that value of BOD in comparision to COD was high in the pre-monsoon season due to high concentration of leachate so that value of BOD/COD greater then post-monsoon season. Some of the researcher have founded that BOD/COD value is less than 0.1 indicating stabilized condition of leachate which means most of the organic matter is nonbiodegradable [20]. This value depends mostly on amount of organic matter content, not on age of the waste**.** In Pune, (Maharashtra) Kale et al. [21] founded BOD/COD value 0.75 in pre-monsoon season and 0.6 in post-monsoon season where MSW was 13 year old, but in Koria, Kim et al in 2009 [20] founded BOD/COD value 0.05-0.07 in leachate of 15 year old MSW. Mean value for SO_4^{2-} founded 1434 mg/l and 2470.3 mg/l in pre-monsoon season, whereas in post-monsoon season was 2227.6 mg/l and 2024.3 mg/l. NO_3^- founded 960.6 mg/l and 2470.3 mg/l in pre-monsoon season, whereas in post-monsoon season was 2227.6 mg/l and 2024.3 mg/l. The higher loading of SO_4^{2-}, NO_3^- may be linked to the landfill which is receiving domestic waste since many years. NH^3-N in the two study area for leachate founded 1434 mg/l and 2470.3 mg/l in pre-monsoon season, whereas in post-monsoon season was 2227.6 mg/l and 2024.3 mg/l. These results are indicating that the leachate of Dubagga landfill site ammonical nitrogen, and nitrate present in leachate. As a time passes organic matter level in leachate decreases while nitrogen content increases. So nitrogen is one of the most significant long-term pollution problem in landfill sites due to nitrogen containing substances in MSW [20]. These pollutants present in the leachate of MSW through mixing with sewage sludge which reaches into the underground water by infiltration through precipitation for leading underground water pollution. The physical and chemical parameters founded in the leachate significantly more concentrated in pre-monsoon season than leachate of post-monsoon season. High concentration of most of the component shows MSW containing all type of the waste from household, commercial, slotter house, clinic, small scale industries and drainage sludge. After precipitation all chemical parameter decreased. The base of the deposited waste is mostly inundated and significant thickness of waste may be submerged and hence quantity of leachate released will be substantially high causing the contamination level to increase in the surrounding area [22]. The conductivity and concentration of chemical pollutants are generally higher in the pre-monsoon season and decreases by simple dilution after monsoon (in post-monsoon season).

4) CONCLUSION

The purpose of study about active (fresh) and closed (old) landfill site was to assess physico-chemical characteristic of leachate in both pre and post-monsoon season. It is neither having liner bottom nor any leachate collection and treatment system. Therefore leachate generate from MSW dumped. All of the physico-chemical parameters observed to come into the conclusion that analytical leachate quality is effected by physical and chemical composition of the MSW which is dumped on open land without any leachate treatment facility still now because of lack of awareness. None of landfill bases is lined, which may result in continuous groundwater contamination near MSW dumping site. The results of the present study may be explore in management for MSW by the municipal authority or citizens and to follow rules which are written in the Indian Gazette, 2000 which would be beneficial for people living near the landfill site in future.

SUGGESTION AND RECOMMENDATION

Dubagga and Aliganj landfill is non-engineered landfill. Remediation measure should be considered by taking into account for both landfill site. Plastic bag and polythene should be strickly segregate before MSW dumping as it takes about 500 years time to be totally decompose [23]. Biodegradables are to be processed by composting, and anaerobic digestion with landfilling restricted to those wastes that are non-biodegradable or inert, or which are not suitable for recycling. Biomedical and industrial wastes must not be mixed with MSW. Municipal authorities have to improve their MSW storage facilities to protect citizen living near landfill which create unhygienic and unsanitary conditions in the area. Parks can be construct on landfill after closure as recommended in Indian Gazette [6]. Monitoring well should be construct for monitoring of leachate. Citizens, municipal authority and NGO must be encouraged providing knowledge about leachte generate from MSW dumped waste to segregate wastes. Specifications for maintenance of landfill sites and various other processing techniques such as composting, treated leachates and incineration are given in the MSWM Rules [6]. People should aware through media and knowledge should provide from childhood education about solid waste management.

REFERENCES

1. US EPA. 1984. United States Environmental Protection Agency (US EPA) Office of Drinking Water, A Ground Water Protection Strategy for the Environmental Protection Agency.
2. Nagarajan, R., S.Thirumalaisamy, and E. Lakshumanan. 2012. Impact of leachate on groundwater pollution due to non-engineered municipal solid waste landfill sites of erode city, Tamil Nadu, India. Iranian J Environ Health Sci Eng., 9(1): 35.
3. Chatterjee, R. 2010. Municipal solid waste management in Kohima city-India. Iranian J Environ Health Sci and Eng. 7(2): 173–180.

4. Census of India. 2011. Ministry of Home Affairs, Government of India (GoI). <http://www.censusindia.net>.
5. Mor, S., Ravindra, K., Vischher, A., Dahiya, R. P. and Chandra, A. 2005a. Municipal Solid Waste Characterisation and its assessment for potential methane generation at Gazipur Landfill Site, Delhi: A case study. Bioresource Technology, Communicated.
6. MoEF. 2000. The Gazette of India. Part II, Section 3, Subsection (ii), No. 648
7. Visvananthan, C., Kuruparan, P., Norbu, T., Trankler, J., Basnayake, B.F.A., Chiemchaisri, C., Kurian, J and Zhou, G.M. 2003. Comparative study on Municipal Solid Waste Management in Asia, ARRPET report.
8. Kurian, J., Nagendran, R. and Palanivelu, K. 2002. "Open dumps to sustainable landfills", CES ENVISION, Monthly newsletter of the ENVIS node under EMCBTA project at CES (AU/CES/NL-02), Supported by MoEF, Government of India, 1, No. 2.
9. Loizidou, M. and E. Kapetanios. 1993. Effect of leachate from landfills on underground water quality. Sci. Total Environ., 128: 69–81.
10. Joseph, K., Esakku, S., Nagendran, R. and Vishvanathan, C. 2005. A decision making tool for dumpsite rehabilitation in developing countries. In: proc Sardinia, Eleventh International waste management and landfill symposium, Italy
11. Sang, N. and Li, G. 2005. Chromosomal aberrations induced in mouse bone marrow cells by municipal landfill Leachate. Environmental Toxicology and Pharmacology 20(1): 219-224.
12. Saarela, J. 2003. Pilot investigations of surface parts of three closed landfills and factors affecting them. Environmental Monitoring Assessment, 84: 183–192.
13. Tatsi, A. and Zouboulis, A. I. 2002. A field investigation of the quantity and quality of leachate from a municipal solid waste landfill in a Mediterranean climate (Thessaloniki, Greece). Advances in Environmental Research, 6(3): 207-219.
14. Esakku, S., Karthikeyan, O. P., Joseph, K., Nagendran, R., Palanivelu, K., Pathirana, K. P. M. N., Karunarathna, A. K. and Basnayake, B .F. A. 2007. Seasonal Variations in Leachate Characteristics from Municipal Solid Waste Dumpsites in India and Srilanka. International Conference on Sustainable Solid Waste Management, 341-347
15. Ferrari, B., Radetski, C. M., Veber, A. M. and Ferard, I. F. 1999. Ecotoxicological Assessment of solid wastes: A Combine liquid and solid phase testing approach using a battery of bioassay and biomarker. Environ. Toxicol. Chem., 18: 1195-1202.
16. APHA. 21st Eds, 1998. Standard Methods for the Examination of Water and Waste Water, American Public Health Association, Washington, DC.
17. APHA-AWWA-WPCF. 15th Eds, 1994. Standards Methods for the Examination of Water and Wastewater, American Public Health Association, Washington DC.
18. Johnson, C. A., Kaeppeli, M., Brandenberger, S., Ulrich, A. and Bauman, W. 1999. Hydrological and geochemical factors affecting leachate composition in MSW incinerator bottom ash. Part II The geochemistry of leachate from landfill Lostorf Switzerland. J contam hydrol., 40: 239-259.
19. Fatta, D., Papadopoulos, A. and Loizidou, M. 1999. A study on the landfill leachate and its impact on the groundwater quality of the greater area. Environ. Geochem. Health, 21(2): 175-190.
20. Kim, Y.D. and Lee, D. G. 2009. Comparative study on leachate in closed landfill sites: focusing on seasonal variations. J Mater Cycles Waste Manag., 11:174–182
21. Kale, S. S., Kadam, A. K., Kumar, S and Pawar, N. J. 2010. Evaluating pollution potential of leachate from landfill site, from the Pune metropolitan city and its impact on shallow basaltic aquifers. Environmental Monitoring Assessment, 162(1-4): 327-46.
22. Census of India. 2011. Ministry of Home Affairs, Government of India (GOI). <http://www.censusindia.net>.
23. Vasanthi, P., Kaliyappan, S. and Srinivasraghvan, R. 2008. Impact of poor solid waste management on groundwater. Environmental Monitoring Assessment, 143: 227-238
24. Juliet, L. 2007. Why my plastic bag still be here in 2507? June 27.